S-2300A

SURFACE ACOUSTIC WAVE STABILIZED OSCILLATORS:

Additional Aging Results

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1.0 INTRODUCTION

This addendum presents and discusses aging data collected during the seven-month period from January 1 to July 31, 1978. Figures 1, 2, and 3 of this addendum correspond to Figs. 5.7 5.8 and 5.9 in the final report. Figure 1 shows the updated aging data for SAW oscillators with aluminum transducers on ST-cut quartz, Fig. 2 shows the data for gold transducers on ST-cut quartz, and Fig. 3 the data for aluminum transducers on $SiO_2/LiTaO_3$. The circled numbers shown on each figure identify the oscillators as listed in Table 5.1 of the final report.

2.0 RESULTS OF THE AGING STUDIES

Oscillators 1, 2, 4, 6, 8, and 9 were all checked for leaks when they were removed from the aging test. Oscillators 4, 6, 8, and 9 were found to have no measurable leaks (leak rate $< 1 \times 10^{-9}$ cc/sec), but No. 1 had a large leak ($> 10^{-4}$ cc/sec) located in the cover seal. Oscillator No. 2 was found to have a leak when it was removed from the test several months ago, but at the time we did not have access to the proper equipment to locate the leak. Oscillators 1 and 2 were the first two oscillators sealed under the contract; all subsequent oscillators used a slightly different sealing procedure. Later devices had a spring clip to hold the cover on the package while the gold-tin solder was melted; the two earlier devices did not. This probably explains why Nos. 1 and 2 leaked, while the others did not.

The package leaks in oscillators No. 1 and 2 were probably responsible for their shift from positive frequency drift to negative drift at 50 and 25 weeks, respectively. The entrance of moisture into the package and its adsorption onto the quartz surface could result in a decreasing frequency, but we cannot prove this conclusively since we have no way of knowing when the leak occurred.

The aging of oscillators 4 and 5 is significantly different from that of Nos. 1, 2, and 3, and is probably related to differences in packaging

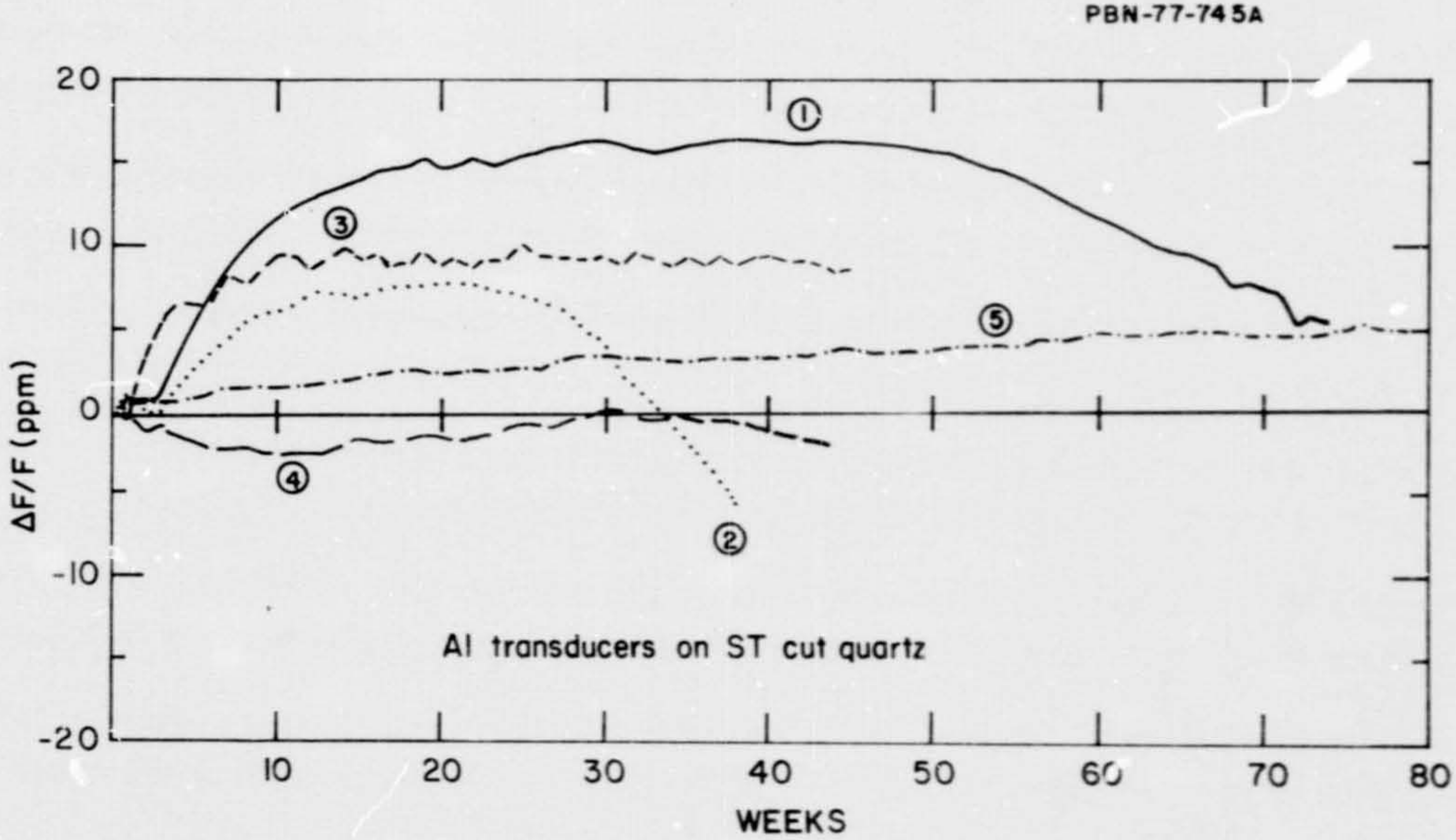

Figure 1 Aging of Devices with Aluminum Transducers on ST-Cut Quartz.

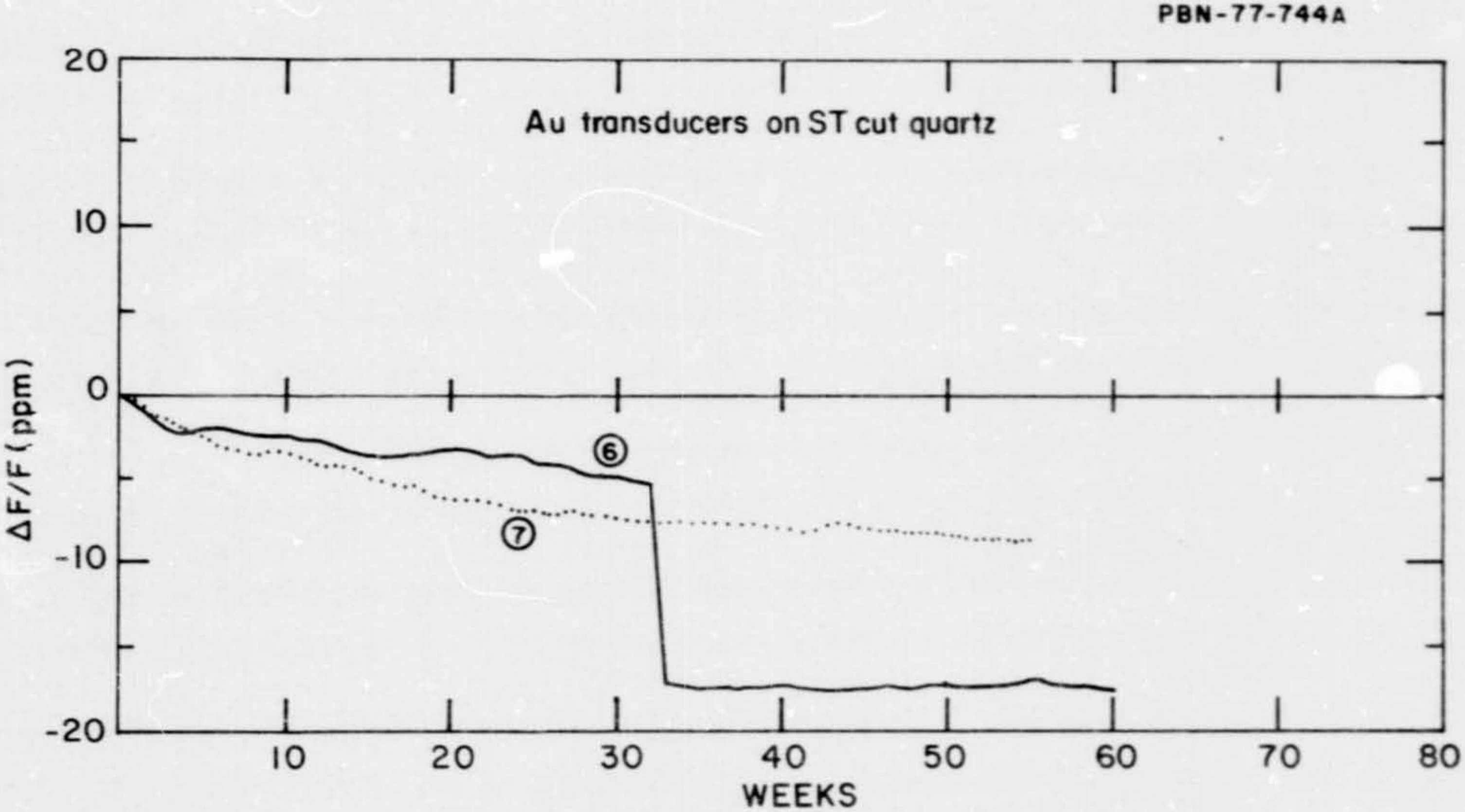

Figure 2 Aging of Devices with Gold Transducers on ST-Cut Quartz.

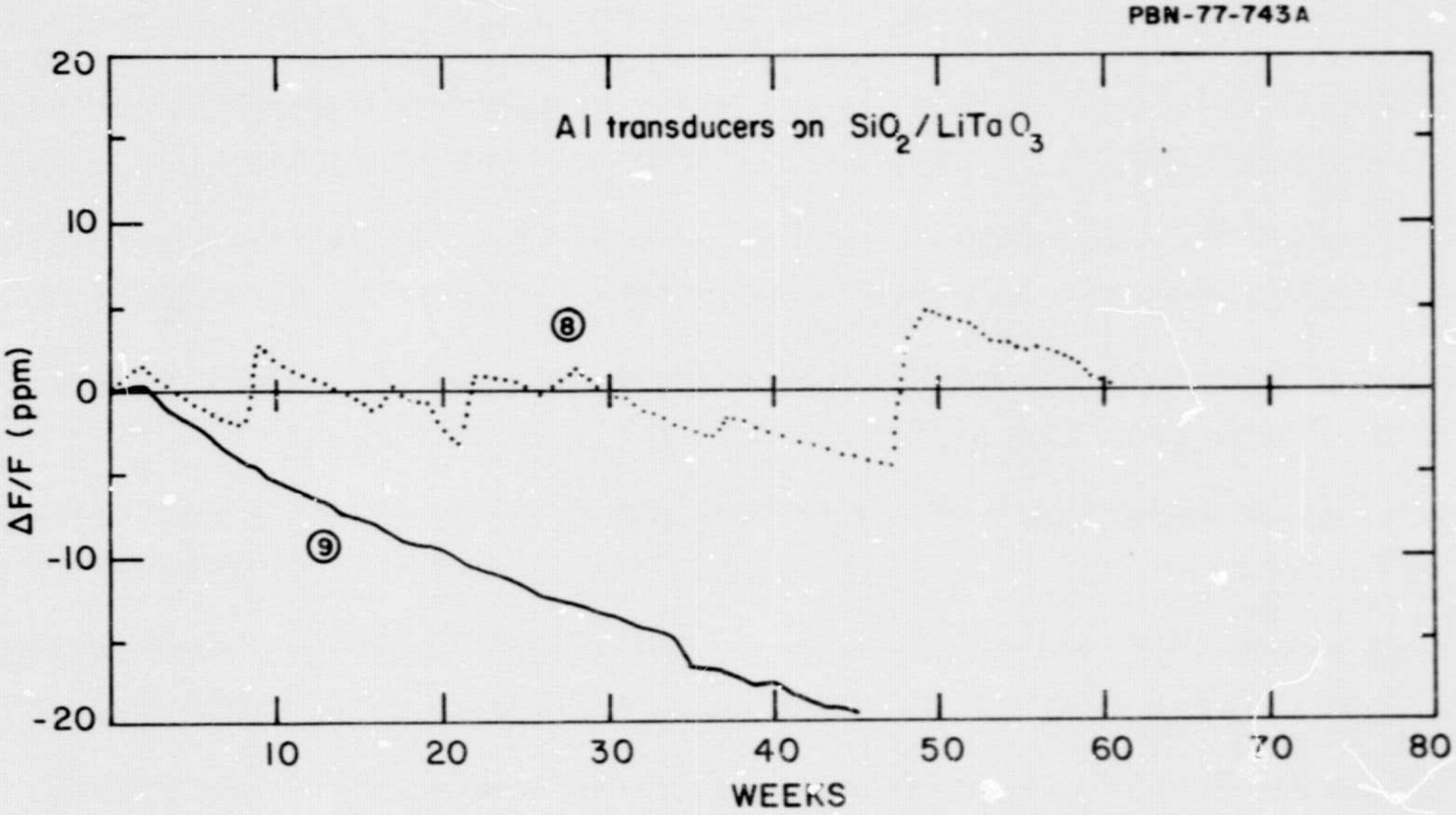

Figure 3 Aging of Devices with Aluminum Transducers on SiO_2/ $LiTaO_3$.

and processing. Oscillator 4 was solder sealed in a flatpack in a manner similar to oscillators 1, 2, and 3, except that, after sealing, No. 4 was baked at 90°C for eleven days before the aging test was begun. Three additional devices (not shown) have since been subjected to a post-sealing bake (welded rather than soldered flatpack). Two of these oscillators are aging like No. 3, and one is aging like No. 4. The data on the effect of a post-sealing bake is therefore inconclusive. All of these devices were mounted with 10-mil wire, and it may be that some time-varying stress is introduced by this mounting technique.

Oscillator No. 5 was sealed in an HC-36/U cold-weld package at ECOM. The packaging of this device was probably significantly cleaner than that used for the others, but there was also a near-six-month period between device fabrication and sealing. The aging test was begun within a week after sealing.

Of the five oscillators having aluminum transducers (Nos. 1 through 5), Nos. 4 and 5 show the lowest total frequency drift, but number 3 shows the lowest rate of drift for an extended period of time. From week 20 to week 41, the drift rate for device No. 4 was -0.25 ppm/year. After 80 weeks of operation, the drift rate of No. 5 is +1.5 ppm/year.

The two oscillators having gold transducers (Nos. 6 and 7) have aged downward from the very beginning. We do not know what caused the sudden drop on No. 6, which occurred over a long holiday week-end between week 32 and week 33. After this drop, No. 6 has aged at a rate of +0.51 ppm/year. Recently a device having gold transducers was sealed at ECOM; after 70 days of operation, this oscillator has drifted less than a total of 0.2 ppm. There was a period of nine months between the fabrication and sealing of this device.

The observation that the devices with gold transducers age differently (both direction and shape of curve) from the devices having aluminum transducers indicates that the transducer metallization can represent an important aging mechanism. Since numerous experiments with bulk-wave quartz crystal oscillators have shown that gold is a more stable electrode material

than aluminum, it is very possible that the upward aging observed with the aluminum transducers is caused by this metallization material. (A number of 160 MHz resonators made with aluminum transducers and aged by Hewlett-Packard showed a similar rapid increase in frequency, followed by a rapid flattening of the aging curve). At this time, we do not know the cause for the downward aging of the gold devices, but it may be a mechanism which is unrelated to transducer metal and therefore may also be present (but masked) in the aluminum device.

Figure 3 shows the aging of the $SiO_2/LiTaO_3$ devices. Number 8 has not drifted more than ± 5 ppm, but it has been very erratic. During periods between sudden upward shifts it has shown a negative drift rate which is similar to number 9, which has drifted downward by nearly 20 ppm. We have no explanation for the erratic jumps of number 8 (it was mounted loosely with 0.003 in. dia. wire); such behavior had not been observed in any of three $SiO_2/LiTaO_3$ devices aged earlier. The aging results do, however, provide strong evidence that the $SiO_2/LiTaO_3$ material ages steeply downward and exhibits relatively little change in the aging rate with time.

REFERENCE

1. C. A. Adams and J. A. Kusters, "Improved Long-Term Aging in Deeply Etched SAW Resonators," Proc. 32nd. Annual Symp. on Frequency Control, (to be published).